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APPENDIX D

QUALITATIVE ANALYSIS OF GENERAL RIVER RESPONSE TO CHANGE

D-1. Introduction. Sufficient hydraulic and sediment data to perform a quantitative analysis is unavailable for the vast majority of Corps' studies and projects. However, this does not preclude a sediment analysis. The analysis must, by necessity, be qualitative in nature. This requires an understanding of fluvial processes [35], [47], and [49].

D-2. General Relationships.

a. Studies conducted by [34], [31], and [48] support the following general relationships according to [49].

(1) Depth of flow y is directly proportional to water discharge Q.

(2) Channel width W is directly proportional to both water discharge Q and sediment discharge Qs.

(3) Channel shape, expressed as width to depth W/y ratio is directly related to sediment discharge Qs.

(4) Channel slope is directly proportional to water discharge Q and directly proportional to both sediment discharge Qs and Grain Size d50.

(5) Sinuosity is directly proportional to valley slope and inversely proportional to sediment discharge Qs.

(6) Transport of bed material Qs is directly related to stream power TAU and concentration of fine material CF, and inversely related to the fall diameter of the bed material d50.

b. Simons [49] developed a relationship for predicting system response to changes in the parameters listed above.

$$Qs \sim [(Gma*D*S) * W * U] / (d50/CF) = [Gma*Q*S] / (d50/CF) \qquad \text{(D-1)}$$

where:

CF = oncentration of fine material load
D = Depth of flow
d50 = Median fall diameter of bed material
Gma = Specific weight of water
Q = Water discharge
Qs = Sediment discharge
S = Channel slope
U = Average velocity
W = Channel width

c. If the specific weight Gma is assumed to be constant and the concentration of fine material CF is incorporated in the fall diameter, the above relationship can be expressed as:

$$Q * S \sim Qs * d50 \tag{D-2}$$

d. The above relationship is identical to that proposed by Lane [31] except that the fall diameter, which includes the effect of temperature on transport, has been substituted for the physical median diameter used by Lane.

D-3. Application of Qualitative Analysis.

a. In order to evaluate natural or imposed changes to a river system with the above equations, the engineer must remember that the proportionality must remain balanced. For example, if median fall diameter and water discharge are assumed constant and a decrease in slope is proposed for a reach of stream, equation (D-2) indicates that the sediment discharge must also decrease.

b. Simons and Senturk [49] offer several good examples of the application of Qualitative Analysis. Two of these are characterized below.

D-4. Drop in Base Level on Main Channel. Figure D-1 shows the effect that a drop in the base level on a main channel has on a tributary stream.

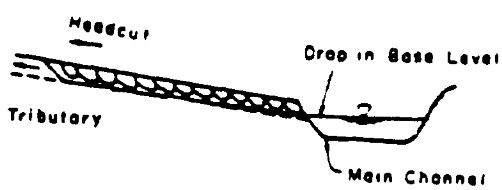

Figure D-1. Lowering base level of tributary stream

By applying the relationship (D-2) to the tributary stream, it can be seen that the increase in slope must be balanced by an increase in sediment transport Qs if the discharge and fall diameter are unchanged.

$$Q * S \sim Qs * d50$$

Therefore, the new slope could induce head-cutting in the tributary stream resulting in bank instability and increased sediment transport from the tributary, an overload of sediment in the main stream, and major changes in the geomorphic characteristics of the stream system.

TABLE D-1. Impact of Change on Stream System

	Local Effects	Upstream Effects	Downstream Effects
1.	Head-cutting	Increased velocity	Increased transport to main cannel
2.	General scour	Increased transport of bed material	Aggradation
3.	Local scour	Unstable channel	Increased flood stage
4.	Bank instability	Possible change in planform of river	Possible change in planform of river
5.	High velocities		

D-5. <u>Effects of In-Channel Structures.</u>

a. Qualitative analysis can be used to analyze the response of reaches on two major tributaries a considerable distance upstream of their confluence. This situation is depicted in Figure D-2.

b. Upstream of Reach A, a diversion structure is built to divert essentially clear water to the adjacent tributary on which Reach B is located. Upstream of Reach B, the clear water diverted from the other channel plus water from the tributary is released through a hydropower plant. Eventually, a large storage reservoir will be constructed downstream of the tributary confluence on the main stem at point C. By altering the normal river flows, these structures initiate several responses on the river system. Through qualitative analysis, it can be seen that Reach A may aggrade due to the excess of sediment left in that tributary when clear water is diverted.

$$Q * S \sim Qs * d50$$

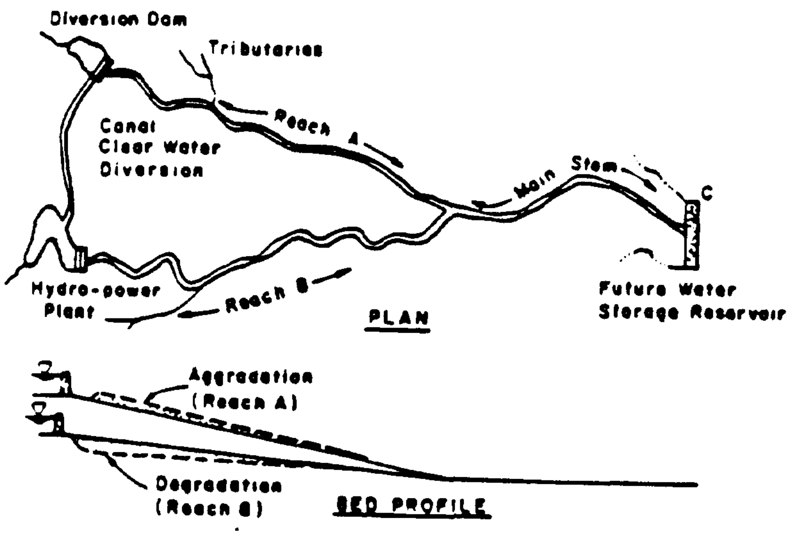

Figure D-2. Clear water diversion and release combined with downstream storage

c. Initially, there may be a lowering of the channel bed downstream of the diversion structure due to deposition upstream of the diversion dam and the initial release of essentially clear water until the sediment storage requirement of the diversion reservoir is satisfied. Reach B is likely to degrade due to the increased discharge and essentially clear water release.

$$Q * S \sim Qs * d50$$

d. It is possible that the degradation in the main channel may induce sufficient head-cutting on tributaries of Reach B to offset additional degradation. See the example of Figure D-1 above. Such changes in a river system are not uncommon. A complete analysis of such a system must consider the effect of each response both individually and collectively.

TABLE D-2. Impact of Change on Stream System

	Local Effects	Upstream Effects	Downstream Effects
1.	Reach A may be subjected to channel aggradation by diversion of clear water due to excess sediment left in the channel after the diversion and degradation in tributaries caused by lowering of their base level	Upstream of Reach A, aggradation and possible change of river form	See upstream
2.	Reach B may be subjected to degradation due to increased discharge in the channel	Upstream of Reach B--aggradation and change of river form	Construction of reservoir C could induce aggradation in the main channel and in the tributaries
3.	If a storage reservoir was constructed at C it could induce aggradation in both tributaries	Channel instabilities	
4.		Significant effects on flood stage	